Methane Savings from Compressors and VRUs

Innovative Technologies for the Oil & Gas Industry: Product Capture, Process Optimization, and Pollution Prevention

Targa Resources and the Gas Processors Association

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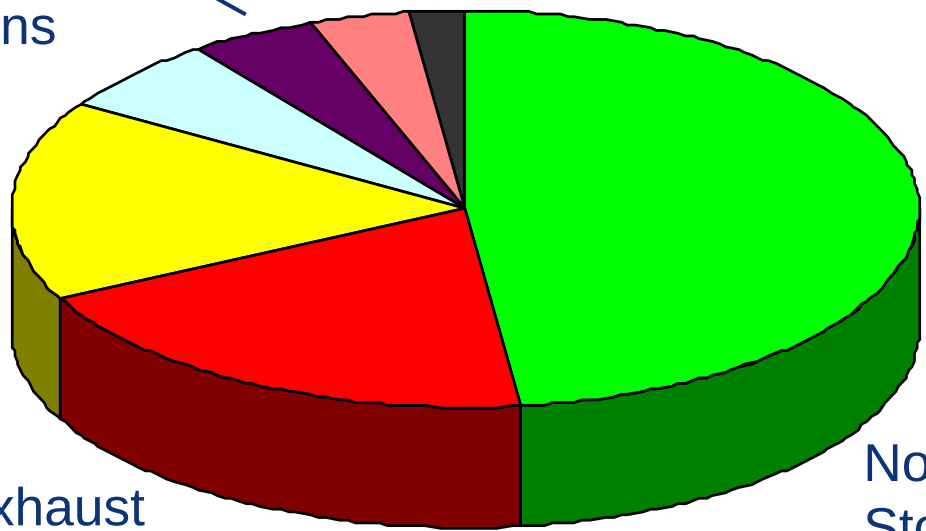
epa.gov/gasstar

Compressors: Agenda

- Methane Losses from Reciprocating Compressors
- Methane Savings through Economic Rod Packing Replacement
- Is Rod Packing Replacement Profitable?
- Methane Losses from Centrifugal Compressors
- Methane Savings through Dry Seals
- Is Wet Seal Replacement Profitable?
- Vapor Recovery Units (VRUs)
- Discussion

Methane Emissions from Natural Gas Processing Sector (2004)

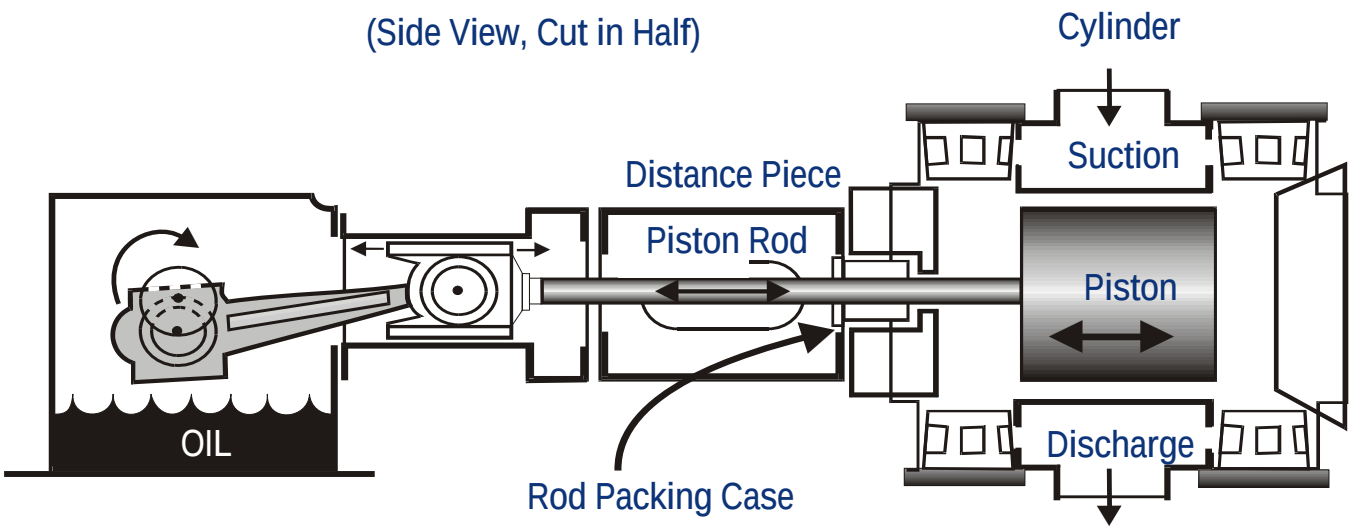


Note:
Storage Tank Venting
from Production = 7 Bcf

Inventory of U.S. Greenhouse Gas Emissions and Sinks 1990 – 2004, USEPA, April, 2006

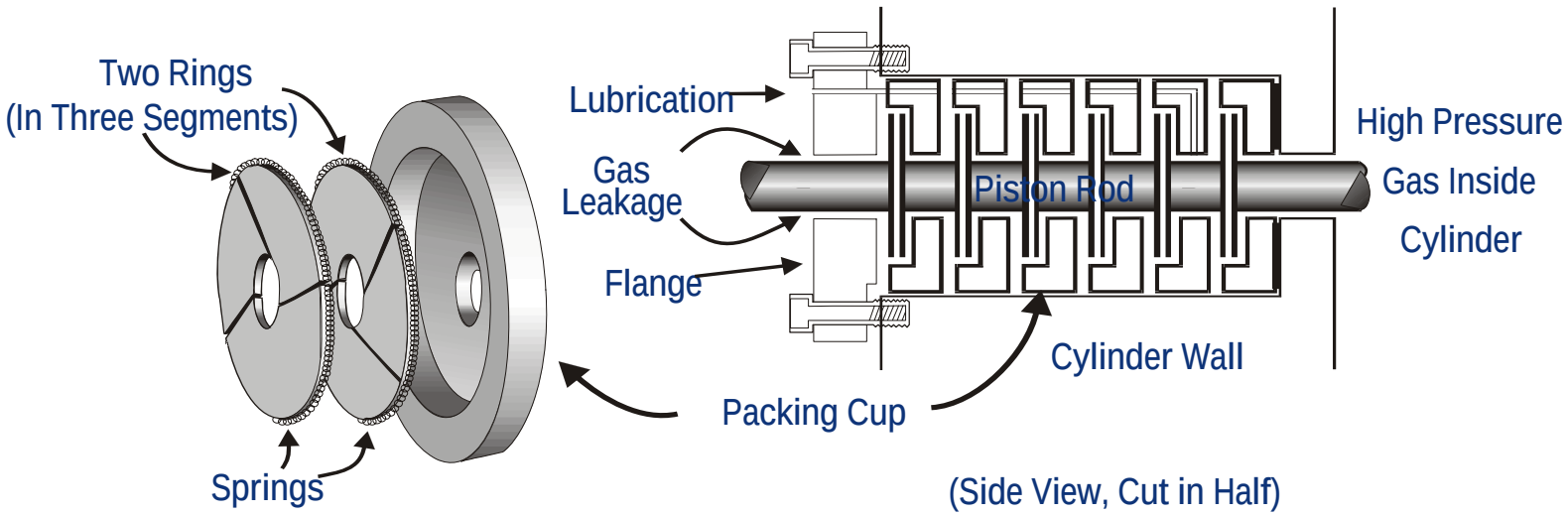
Methane Losses from Reciprocating Compressors

- Reciprocating compressor rod packing leaks some gas by design
  - Newly installed packing may leak 60 cubic feet per hour (cf/hr)
  - Worn packing has been reported to leak up to 900 cf/hr



Reciprocating Compressor Rod Packing

- A series of flexible rings fit around the shaft to prevent leakage
- Leakage may still occur through nose gasket, between packing cups, around the rings and between rings and shaft



Methane Losses from Rod Packing

Emission from Running Compressor	99	cf/hour-packing
Emission from Idle/Pressurized Compressor	145	cf/hour-packing
Leakage from Packing Cup	79	cf/hour-packing
Leakage from Distance Piece	34	cf/hour-packing

Leakage from Rod Packing on Running Compressors				
Packing Type	Bronze	Bronze/Steel	Bronze/Teflon	Teflon
Leak Rate (cf/hour)	70	63	150	24

Leakage from Rod Packing on Idle/Pressurized Compressors				
Packing Type	Bronze	Bronze/Steel	Bronze/Teflon	Teflon
Leak Rate (cf/hour)	70	N/A	147	22

Source: Cost Effective Leak Mitigation at Natural Gas Transmission Compressor Stations – PRCI/ GRI/ EPA

Methane Savings Through Economic Rod Packing Replacement

- Assess costs of replacements
  - A set of rings: $ 500 to $ 800
    (with cups and case) $1500 to $2500
  - Rods: $1800 to $10000
    - Special coatings such as ceramic, tungsten carbide, or chromium can increase rod costs
  - Determine economic replacement threshold
  - Partners can determine economic threshold for all replacements

Economic Replacement Threshold (scfh) = $\frac{CR * DF * 1{,}000}{(H * GP)}$

Where:

CR = Cost of replacement ($)
DF = Discount factor (%) at interest *i*
H = Hours of compressor operation per year
GP = Gas price ($/Mcf)

$$DF = \frac{i(1+i)^n}{(1+i)^n - 1}$$

Is Rod Packing Replacement Profitable?

- Periodically measure leakage increase

Rings Only		Rod and Rings	
Rings:	$1,200	Rings:	$1,200
Rod:	$0	Rod:	$7,000
Gas:	$7/Mcf	Gas:	$7/Mcf
Operating:	8,000 hrs/yr	Operating:	8,000 hrs/yr

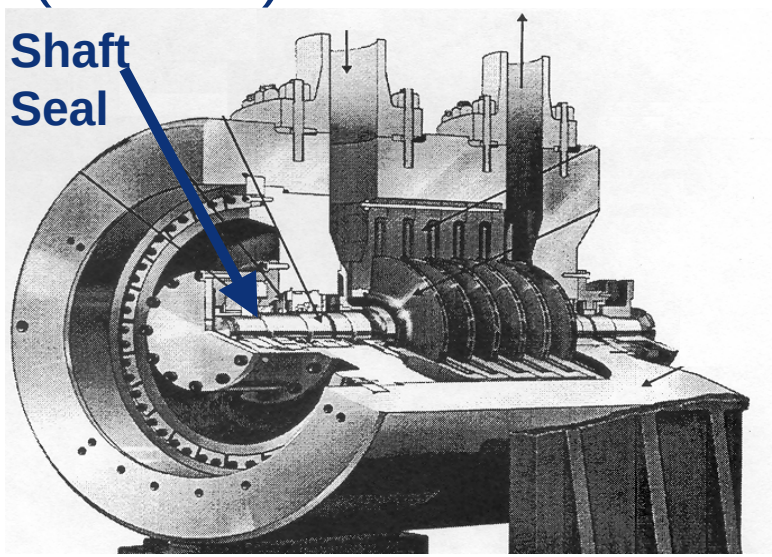
Leak Reduction Expected (scfh)	Payback (yr)
21.4	1
10.7	2
7.1	3
5.4	4

Leak Reduction Expected (scfh)	Payback (yr)
146.4	1
73.2	2
48.8	3
36.6	4

Based on 10% interest rate
Mcf = thousand cubic feet, scfh = standard cubic feet per hour

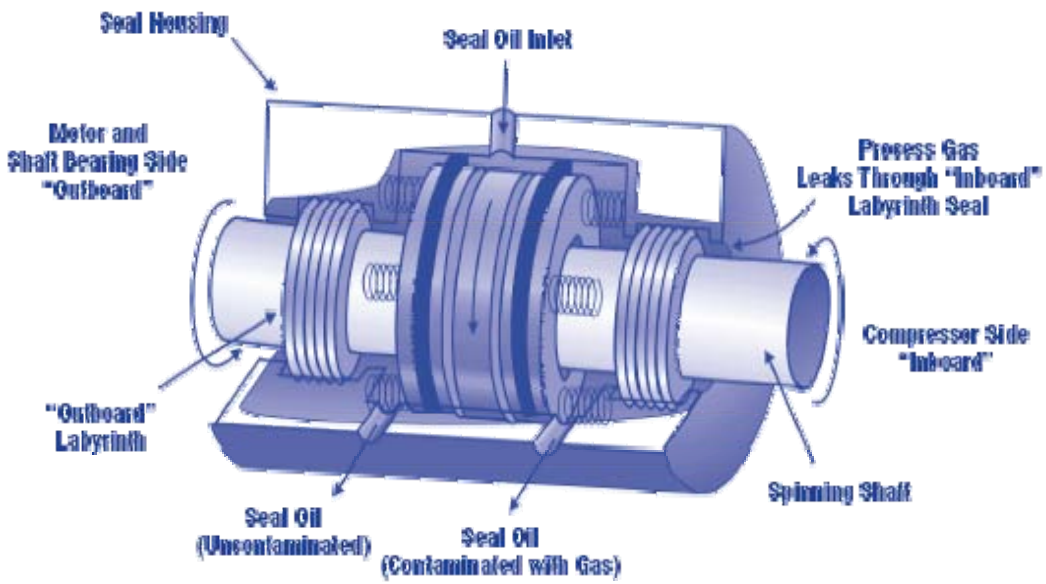
Methane Losses from Centrifugal Compressors

- Centrifugal compressor wet seals leak little gas at the seal face
  - Seal oil degassing may vent 40 to 200 cubic feet per minute (cf/m) to the atmosphere
  - A Natural Gas STAR partner reported wet seal emissions of 75 Mcf/day (52 cf/m)



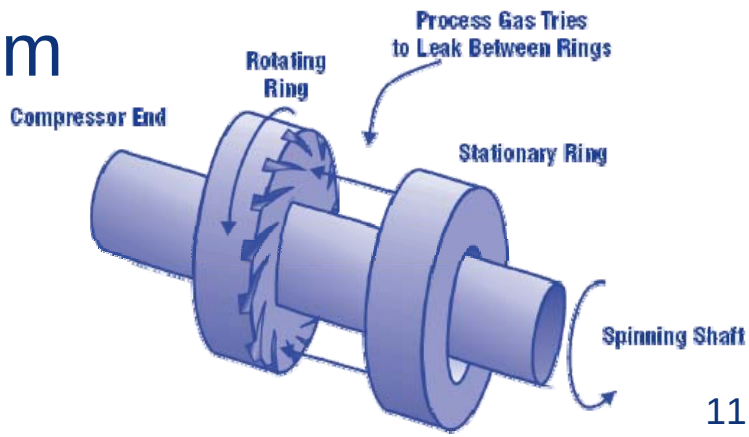
Centrifugal Compressor Wet Seals

- High pressure seal oil circulates between rings around the compressor shaft
- Gas absorbs in the oil on the inboard side
- Little gas leaks through the oil seal
- Seal oil degassing vents methane to the atmosphere



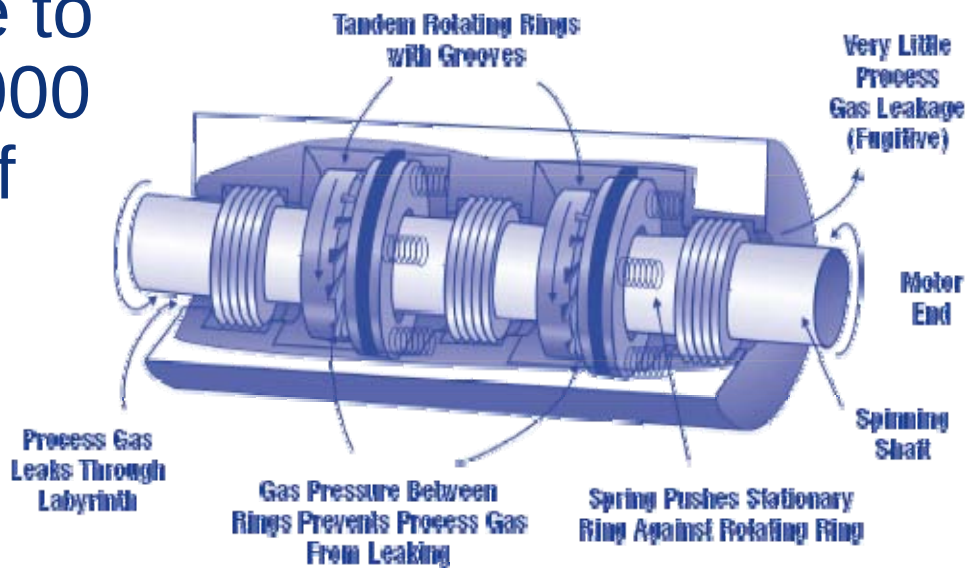
Natural Gas STAR Partners Reduce Emissions with Dry Seals

- Dry seal springs press the stationary ring in the seal housing against the rotating ring when the compressor is not rotating
- At high rotation speed, gas is pumped between the seal rings creating a high pressure barrier to leakage
- Only a very small amount of gas escapes through the gap
- 2 seals are often used in tandem
- Can operate for compressors up to 3,000 psig safely



Methane Savings through Dry Seals

- Dry seals typically leak at a rate of only 0.5 to 3 cf/m
  - Significantly less than the 40 to 200 cf/m emissions from wet seals
- Gas savings translate to approximately $112,000 to $651,000 at $7/Mcf



Economics of Replacing Seals

- Compare costs and savings for a 6-inch shaft beam compressor

Cost Category	Dry Seal ($)	Wet Seal ($)
Implementation Costs[1]		
Seal costs (2 dry @ $10,000/shaft-inch, w/testing)	$120,000	
Seal costs (2 wet @ $5,000/shaft-inch)		$60,000
Other costs (engineering, equipment installation)	$120,000	$0
Total Implementation Costs	$240,000	$60,000
Annual O&M	$10,000	$73,000
Annual Methane Emissions (@ $7/Mcf; 8,000 hr/yr)		
2 dry seals at a total of 6 scfm	$20,160	
2 wet seals at a total of 100 scfm		$336,000
Total Costs Over 5-Year Period	$390,800	$2,105,000
Total Dry Seal Savings Over 5 Years		
Savings	$1,714,000	
Methane Emissions Reductions (Mcf; at 45,120 Mcf/yr)	225,600	

[1] **Flowserve Corporation**

Is Wet Seal Replacement Profitable?

- Replacing wet seals in a 6 inch shaft beam compressor operating 8,000 hr/yr
  - Net Present Value = $1,216,100
    - Assuming a 10% discount over 5 years
  - Internal Rate of Return = 171%
  - Payback Period = 7 months
    - Ranges from 4 to 15 months based on wet seal leakage rates between 40 and 200 cf/m
- Economics are better for new installations
  - Vendors report that 90% of compressors sold to the natural gas industry are centrifugal with dry seals

The Heart of a VRU is the Compressor

- Reciprocating and Centrifugal compressors are best in dry gas service – NOT vapor recovery
  - Vapor recovered from storage tanks will be “wet” gas (at the liquid saturation point)
  - Wet gas fouls the valves & seals/ compromises lube oil
- VRU installations commonly use compressors that work well with wet gas

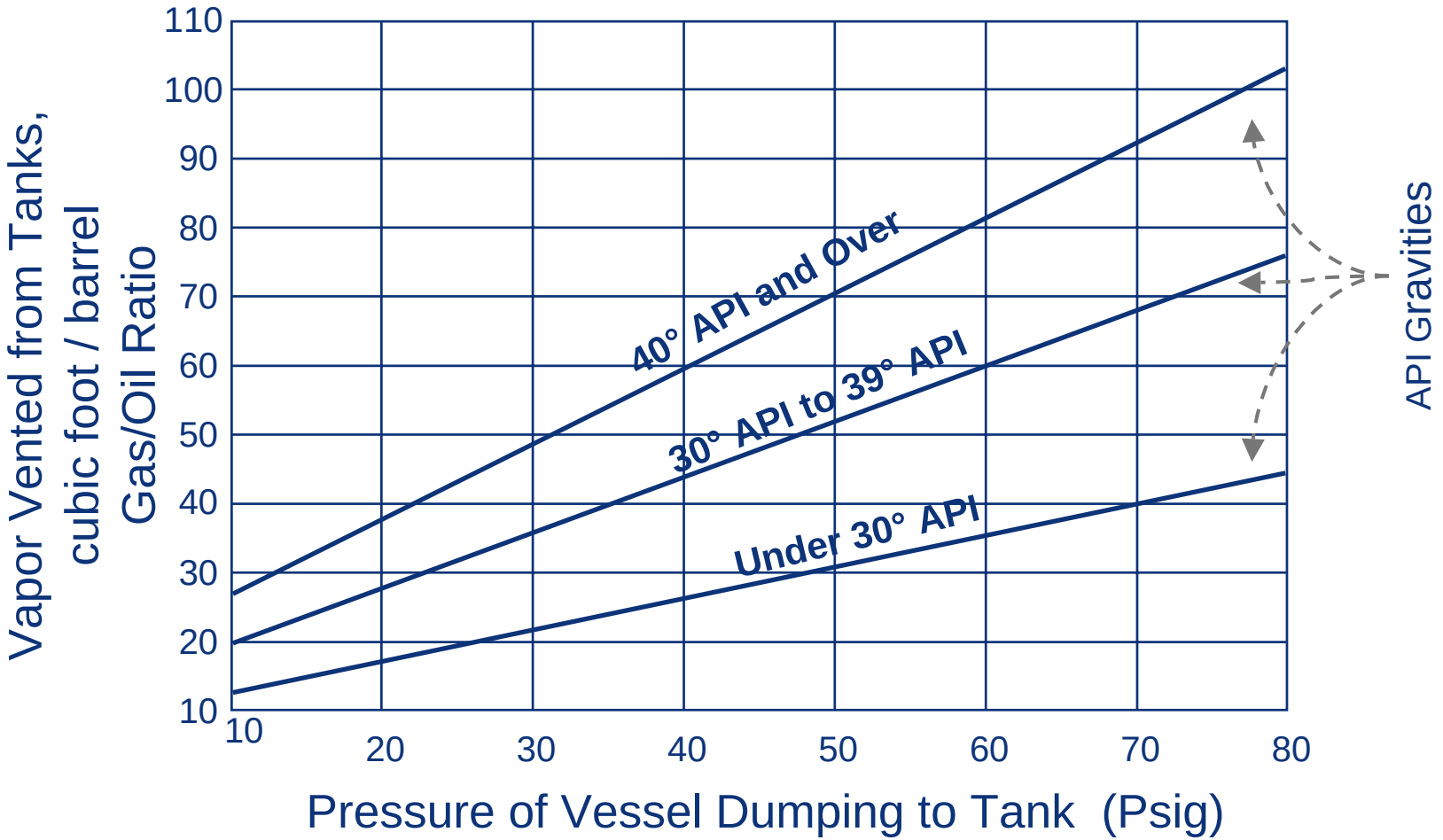
Options for Vapor Recovery Units

- Recommended choices
  - Rotary compressors – require electrical power or engine driver
  - Sliding Vane or Rotary Screw Compressors
  - Scroll compressors
- Alternative, niche technologies
  - EVRU™ – replaces rotary compressor and contains no moving parts
  - Vapor Jet system - requires high pressure water motive
- Choices not recommended
  - Reciprocating compressors
  - Centrifugal compressors

Vapor Recovery - Sources of Methane Losses

- Flash losses
  - Occur when crude is transferred from a gas-oil separator at higher pressure to a storage tank at atmospheric pressure
- Working losses
  - Occur when crude levels change and when crude in tank is agitated
- Standing losses
  - Occur with daily and seasonal temperature and barometric pressure changes

Estimated Volume of Tank Vapors



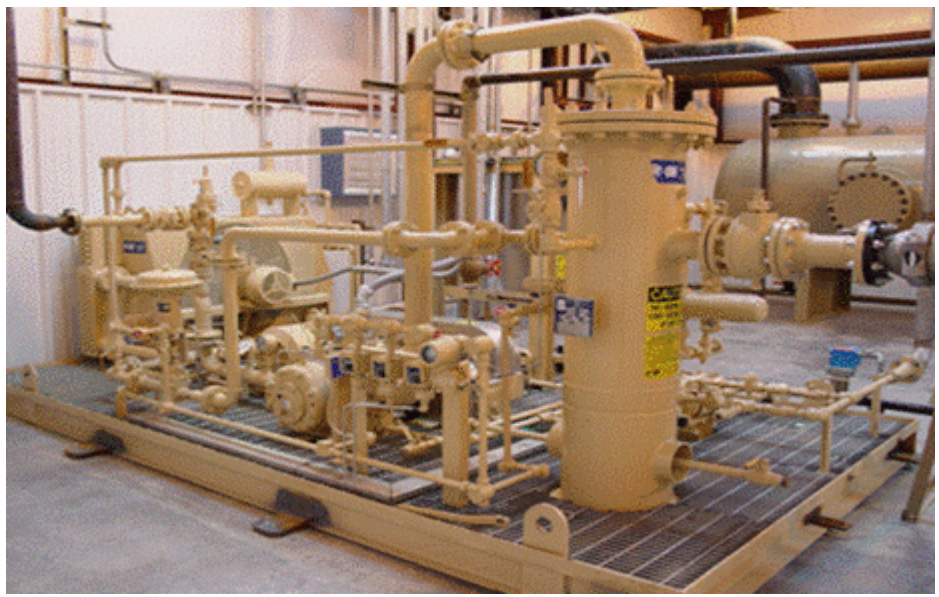
° API = API gravity

Is It REALLY that much gas?

- Video Clip

Vapor Recovery Installations

Vapor Recovery Installations



Criteria for Vapor Recovery Unit Locations

- Steady source and sufficient quantity of losses
  - Crude oil stock tank
  - Flash tank, heater/treater, water skimmer vents
  - Gas pneumatic controllers and pumps
- Outlet for recovered gas
  - Access to low pressure gas pipeline, compressor suction, or on-site fuel system
- Tank batteries not subject to air regulations

What is the Recovered Gas Worth?

- Value depends on heat content of gas
- Value depends on how gas is used
  - On-site fuel
    - Valued in terms of fuel that is replaced
  - Natural gas pipeline
    - Measured by the higher price for rich (higher heat content) gas
  - Gas processing plant
    - Measured by value of natural gas liquids and methane, which can be separated

Is Recovery Profitable?

Financial Analysis for a conventional VRU Project						
Peak Capacity (Mcf / day)	Installation & Capital Costs[1]	O & M Costs ($ / year)	Value of Gas[2] ($ / year)	Annual Savings	Simple Payback (months)	Return on Investment
25	26,470	5,250	$ 51,465	$ 46,215	7	175%
50	34,125	6,000	$ 102,930	$ 96,930	5	284%
100	41,125	7,200	$ 205,860	$ 198,660	3	483%
200	55,125	8,400	$ 411,720	$ 403,320	2	732%
500	77,000	12,000	$ 1,029,300	$ 1,017,300	1	1321%

1 Unit Cost plus estimated installation at 75% of unit cost

2 $11.28 x 1/2 capacity x 365, Assumed price includes Btu enriched gas (1.289 MMBtu/Mcf)

Discussion

- Industry experience applying these technologies and practices
- Limitations on application of these technologies an practices
- Actual costs and benefits
- Leased compressors
  - Control over seal type and maintenance?